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Garzón, C., Miranda, E., Martínez-Cisneros, C., Alonso, J., García-García, J. (2011). Method for improving the electrostatics perforation pattern using power controlled discharges. *Journal of Physics: Conference Series*, v. 301, 012016, pp.: 1-4.

DOI: <https://doi.org/10.1088/1742-6596/301/1/012016>

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2011 J. Phys.: Conf. Ser. 301 012016

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Method for improving the electrostatics perforation pattern using power controlled discharges

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Abstract. The aims of this work are to show the influence of adding a series resistance at the output of a discharge generator circuit and to point out that this component can be used to control the spark energy in electrostatic perforation systems. Analysis of the experimental results reveals that there exists a close connection between the resistor value and the obtained perforation pattern both in hole density and size. The use of a series resistor has a strong influence on the material porosity, which is an important industrial parameter for assessing the pattern perforation quality.

1. Introduction

Electrical Discharge Machining (EDM) is used to drill and mechanize a wide variety of rigid materials that are difficult to cut or shape by more standard tools because of their hardness or complex shape. The EDM operating principle is based on the interaction between solid matter and the electric arc discharge. The severe physical conditions around the spark can be used to mill and drill nearly all kinds of material [1]. Electro-perforation is a particular case of EDM that allows holes to be made in permeable materials such as paper webs or biological membranes so as to obtain a drilling pattern with controlled porosity. Depending on the application considered it is sometimes necessary or convenient to achieve a specific hole size target.

Hole patterns must meet certain specifications to be considered appropriate for industrial applications. One of the most important parameters that needs to be taken into account to evaluate the quality of the perforation pattern is the material porosity. Quite often holes must be imperceptible to the human eye.

In previous work [2], the authors have investigated the relationship between the electrode distance and the perforation density and defined the drag distance as the minimum separation needed to generate a second hole in a specific area.

2. Experimental Results and Analysis.

The experimental setup consists of an array of two programmable step motors Zaber T-LSQ075D [3]. The motors are fixed to an optic table and move the sample in horizontal and vertical sweeps. The discharges take place between two tungsten electrodes (see Figure 1). The motors have 75 mm travel range, 550mm/s maximum speed and an accuracy of $\pm 20\mu\text{m}$. The gap in between the electrodes is around 3 mm. The custom-built equipment generates discharge trains up to 100 Hz. Work is in

progress to generate higher frequency ranges using IGBTs-based electronics. The tests were made controlling the power discharge of the spark generator circuit. At this stage, the control simply consists of adding a series resistor in the output circuit but more elaborate electronics is underway.

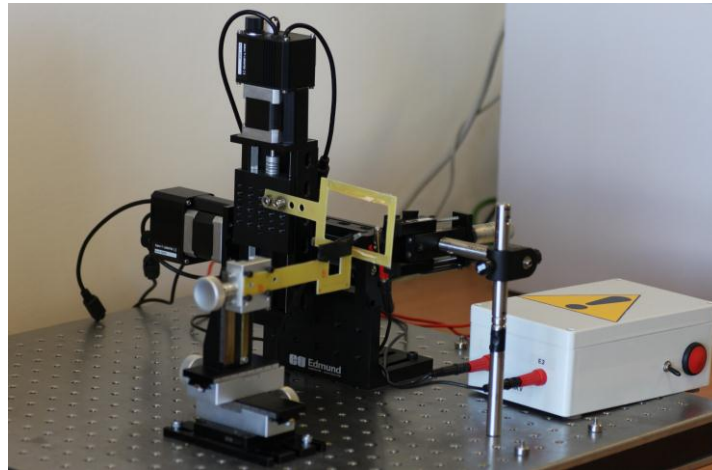


Figure 1. Experimental setup for the electroporation.

Figures 2 and 3 illustrate the power control effects on the perforation pattern with and without the inclusion of the series resistance in the output circuit, respectively. In order to assess the quality of the perforation process it is convenient to use statistical tools such as the Spatstat package of R language [4].

It is worth noting that the incorporation of a series resistance yields a 60% increase in the number of points per unit area and that the average hole size is reduced by of about 53%. It is clear from these observations that the proposed method can be used to control the perforated area visibility in the industrial process.



Figure 2. Perforation pattern with power discharge control (average hole size 0.22 mm)

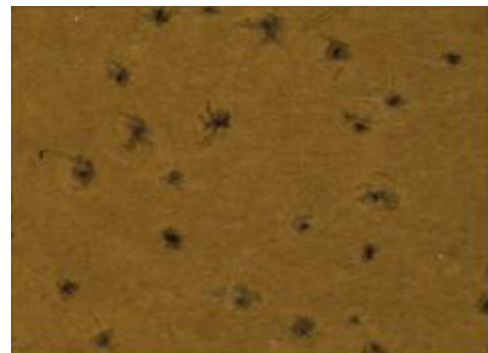


Figure 3. Perforation pattern without power discharge control (average hole size 0.48 mm)

Additionally, the mean drag distance reduces from 0.27mm to 0.21 mm in patterns generated with controlled discharges (Figure 2), i.e. when the resistor (with different values between 200 Ω to 1.5k Ω) is introduced in the output circuit. These estimations are obtained using statistical tools such as the cumulative distribution function (CDF) for the nearest neighbour distance [4]. With CDF (Figure 4) it is possible to estimate the most frequent distance between nearest neighbour holes and to describe the

probability distribution for each distance value. Figures 5 and 6 show two histograms for the distance to nearest neighbours in patterns made with and without controlled discharges.

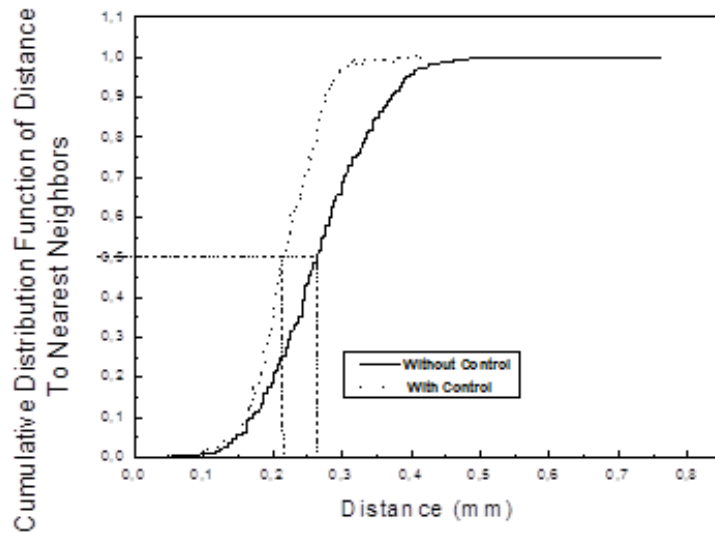


Figure 4. Cumulative distribution function of distance to nearest neighbours.

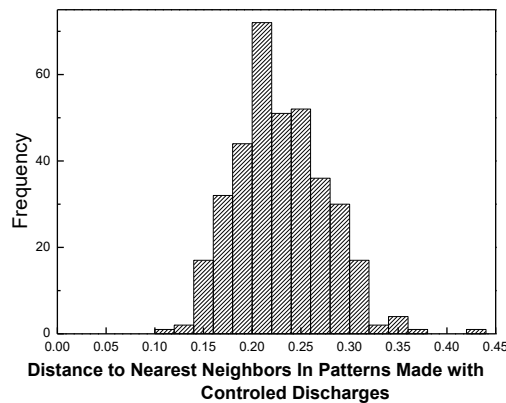


Figure 5. Distance to nearest neighbour in patterns made with controlled discharges (mm)

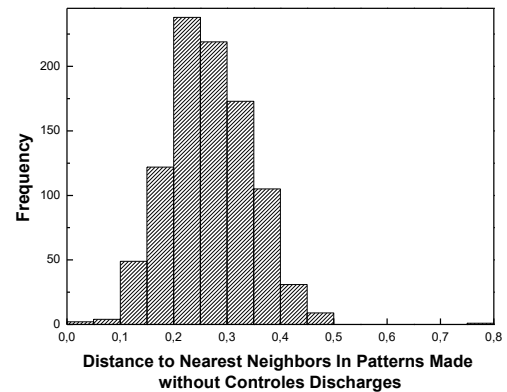


Figure 6. Distance to nearest neighbour in patterns made without controlled discharges (mm)

The porosity is another parameter that is affected by the implementation of the output resistor. Several measurements were made using different resistor values and the results are shown in Figure 7. There is a porosity increase linked to an increased resistance value and its trend line can be described by a 3rd order polynomial expression.

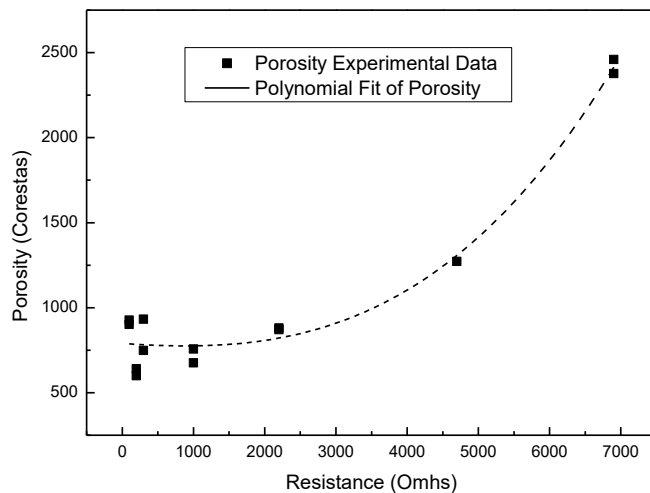


Figure 7. Porosity trend of paper webs perforated with different values of output resistors.

3. Conclusions

In summary, it is shown that it is possible to adjust different parameters of the perforations by using resistors in a typical electro-perforation process.

The porosity increment is the most important parameter for industry and the obtained results show that it is possible to achieve high porosity making holes small enough to reduce the visibility of the perforated areas in an industrial process. This is possible by reducing the drag distance and the consequent increase of holes per unit area due to the power controlled discharges.

References

- [1] Ho, K.H.; Newman, S.T. "State of the art electrical discharge machining (EDM)" 2003 Int. J. Mach.Tools Manuf. 41. 1257-1300.
- [2] Garcia-Garcia, J; Miranda, E; Martinez-Cisneros, CS, et al. "Porosity enhancement by the utilization of screening patterns in electroperforated paper webs",2010 J. Electrostatics 68. 196-199
- [3] http://www.zaber.com/products/product_detail.php?detail=TLSQ075D&tab=Detailed%20Specs
- [4] <http://www.r-project.org/>